The study of noise emission from machinery by using the mobile measurement system

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Abstract

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For many years, noise has remained the most common harmful factor in the work environment in Poland. In industrial conditions, there are often multiple sources emitting noise. Measurements of the quantities characterizing the noise emission of industrial machines are extremely important from the point of view of protecting humans from noise. The results of these measurements are essential for developing solutions aimed at noise reduction using technical or administrative-organizational means. Noise emission measurements of machines are mandatory in cases strictly defined by law. From the employer's perspective, the results allow for determining the working conditions for machine operators and those in their vicinity. Commonly used measurement methods have their limitations, some of which can be mitigated by employing modern technical solutions. However, there are still few improvements in methods designed to determine noise emission parameters, especially in the area of using modern measurement probes and the actual process of conducting measurements in in situ conditions. Among the methods for determining the sound power of machines in in situ conditions, intensity-based methods are important. Some of the assumptions of these methods seem very difficult for the person conducting the measurements to meet. Moreover, there are no reports in the literature on how potential deviations from the guidelines may affect the measurement results and ultimately the determined sound power. This issue was the main focus of this dissertation.

Measurements necessary for determining noise emission parameters are often multi-point measurements of varying complexity. Current global trends are focused on innovative approaches and the introduction of new solutions aimed at locating emission sources, without focusing on solutions dedicated to standardized measurements. Standardized methods themselves also do not account for technical advancements in measurement technology, which could potentially improve their efficiency and scope of use. This dissertation is an attempt to introduce innovations in this field.

The aim of the dissertation is to develop a research tool to support the performance of studies on noise emission parameters and analyze the potential of its use in research related to determining the sound power of machines using the scanning method.

The thesis put forward in this study is:

It is possible to create a mobile measurement system to assist in conducting measurements aimed at examining the noise parameters emitted by machines.

Additionally, two research hypotheses were adopted:

Hypothesis 1:

It is possible to use a mobile measurement system to support the performance of measurements necessary for determining sound power levels in in situ conditions.

Hypothesis 2:

The use of a mobile measurement system for scanning to determine the sound power levels of machines based on sound intensity measurements will ensure greater repeatability of measurement results compared to measurements in which scanning is performed manually.

The scope of the work carried out included the development of the concept of the mobile measurement system, its creation, and validation. The validation of the mobile measurement system was a key process that allowed for an assessment of the potential of the developed tool. Four sub-areas were defined for validation studies:

- Noise emitted by the mobile measurement system – crucial in terms of the utility of the developed system in studies of machine noise emissions.
- Positioning accuracy – influencing the correct placement of the measurement transducer in the designated location.
- Positioning repeatability – affecting the repeatability of the measurement transducer settings in given locations, and thus the repeatability of measurement results for stationary noise measurements over time.
- Vibrations occurring at the installation site of the measurement transducer – allowing for the determination of their impact on the results of the measurements conducted.

The main part of the dissertation is focused on studies related to determining the sound power of three sources. One source was placed in an acoustic test chamber, and two others were located in a machine hall (in situ conditions). The studies were conducted with the participation of three operators, performing manual measurements as well as using the mobile measurement system. The research process was based on the intensity method described in the PN-EN ISO 9614-2 standard for Class 2, also considering some elements of the PN-EN ISO 9614-3 standard

for Class 1. Their implementation served as a kind of "case study," which not only highlighted the challenges of the scanning method but also examined to what extent the mobile measurement system could help in eliminating them. In total, 14 partial measurement surfaces were adopted for all sources, and the scanning process by the operators was carried out using meandering paths in two variants, with three trials per variant. A three-directional intensity probe with direct measurement of acoustic velocity was selected as the measurement transducer. The Scan & Paint 3D system was used to track the trajectory of the probe movement. The results of the studies were analyzed, focusing on parameters such as scanning times, the percentage fill factor of partial surface segments with measurements, and differences in partial sound power levels between two scanning trials conducted on the same partial surface. Statistical analyses were conducted, showing, among other things, significantly higher values of the fill factor of partial surface segments for all accepted measurement path deviation tolerances relative to the partial surface. The statistical significance of the differences between the medians of partial sound power in third-octave bands for individual partial surfaces was also demonstrated. The obtained results allowed for the confirmation of the research hypotheses and the thesis of the dissertation.